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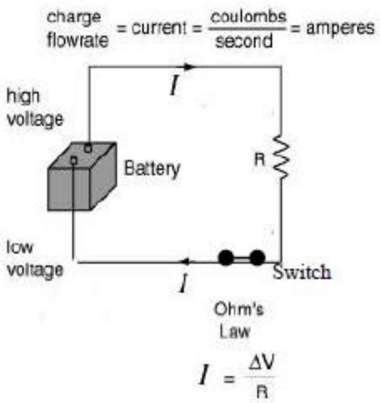
APPENDIX 1

Analogy of fluid flow in a pipe for Ohm's Law (Glynn, 1997)

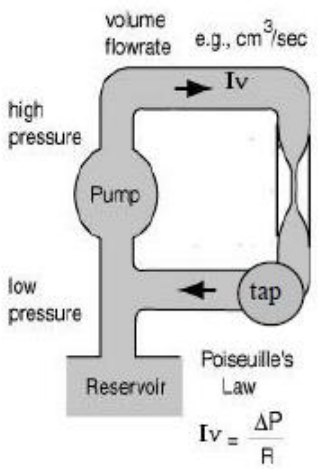
a. *Introducing the target*

To introduce the concept of unidirectional electric current, a simple circuit is prepared with voltage source components, conductive wire, and an obstacle as shown in Figure 2.1



b. *Delivering analog*

The concept used as an analog of the concept of unidirectional electric current is a series of fluids in a pipeline that is supplied with the help of a pump and a fluid resistance which is analogous to a barrier, as in Figure 2.2.



Related Article:
Djudin T and Grapragasem S. The Use of Pictorial Analogy to Increase Students' Achievement and Its Retention of Physics Lessons of Direct Current. *Jurnal Penelitian Fisika dan Aplikasinya (JPFA)*. 2019; **9**(2): 140-151. DOI: https://doi.org/10.26740/jpfa.v9n2.p140-151.

c. Identifying the relevant properties between analog and target

Table 2.1 Relevant properties of the analog-target in a direct electric circuit

Target	Analog
Amount of electric charge flowing in conductor per unit time (electric current strength)	The amount of fluid flowing in the conductor of each unit of time (fluid discharge)
The amount of electric current is influenced by the potential difference in the power source (I ∞ V)	Fluid flow (fluid volume rate) is affected by the difference in pressure on the pump (Ifluid ∞ ΔP)
The amount of electric current is influenced by the amount of resistance in the circuit (I ∞ 1 / R)	Fluid flow (fluid volume rate) is affected by resistance density (Ifluid ∞ 1 / R)
Barriers in electrical circuits act as inhibitors of flowing electric current	Fluid resistance in the circuit can inhibit the flow of fluid, with the provision that the more tight the resistance, the greater the obstacle.

d. Mapping the target and analogue relevant properties

Through the similarities / similarities between targets and analogues, it can be mapped as in table 2.2.

Table 2.2 Mapping the relevant properties of a directional analog-electric circuit

Target	Analog
Electrical charge	Amount of fluid (volume of fluid)
Electric current	Fluid volume rate (discharge)
Obstacles	Fluid resistance
Electrical voltage	Fluid pressure
Potential difference	Pressure difference
Voltage source	Fluid pump
Delivery wire	Pipe
Ohm's Law	Poiseuille Law
Electric current strength = (potential difference) / resistance	Fluid flow rate = (pressure difference) / resistance

e. Identifying analogous properties that are not relevant to the nature of the target

Table 2.3 Properties that are irrelevant between analog-targets

Analog	Target
Fluid loading moves from high potential to low potential	In the direction of electricity, what moves is electrons from low potential to high potential. The positive charge of electricity is only the result of electron displacement.

f. Drawing conclusions

Fluid flow flows from high pressure to lower pressure. The amount of fluid volume depends on the magnitude of the difference in pressure and the amount of resistance passed by the fluid. The greater the pressure difference between the ends of the pump, the greater the volume of fluid that will flow in the pipe. Meanwhile, the greater the resistance on the pipe will result in the smaller the volume of water. In other words, the volume rate of the fluid flowing in the pipe is proportional to the difference in pump pressure, and inversely proportional to the temperature of the pipe.

The same thing happens in direct current electricity. An electric current is an electric charge that flows time unity in an electrical circuit because of the potential difference between the pole (+) and the pole (-) of the source of the ground. Electric current strength can be determined by comparing the amount of charge flowing with the time interval, that is, with the equation $I = Q / t$. The magnitude of the electric current flowing in the circuit is directly proportional to the magnitude of the electrical potential difference ($I \infty V$), and inversely proportional to the resistance (I (1 / R). This is in accordance with Ohm's Law equation, namely: $I = V / R$